



U.S. Army School of Aviation Medicine

Aviation Toxicology

Terminal Learning Objective

- ◆ ACTION: Identify the toxic hazards in the aviation environment
- ◆ CONDITION: While serving as an aircrew member
- ◆ STANDARD: IAW TC 3-04.93, AR 50-5, AR 50-6 and Fundamentals of Aerospace Medicine

Administrative Information

- ◆ Risk Assessment: Low
- ◆ Environmental Considerations: None
- ◆ Safety Considerations: None
- ◆ Evaluation: 50 Question exam at the end of Aeromedical Training at USASAM

ELO A

- ◆ ACTION: Identify the elements of an Occupational Health Program in Army Aviation
- ◆ CONDITION: Given a list
- ◆ STANDARD: IAW TC 3-04.93, Fundamentals of Aerospace Medicine, and Occupational Health in Aviation

History of Occupational Medicine in Aviation

- ◆ Occupational Medicine is an essential component of the Army Aviation Medicine Program
- ◆ To prevent and solve problems involving potential toxic hazards in the aviation environment
- ◆ Hippocrates (400 B.C.)
 - ▶ First to describe the relationship between work and illness
 - ▶ First discussed principles of toxicology during research to control the absorption of a compound to prevent overdose

History of Occupational Medicine in Aviation

- ◆ “All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy.”

-Paracelsus (16th Century)



- ◆ Bernardino Ramazzini's book “De Morbis Artificum” described numerous diseases caused by exposure to toxins in the work environment; some of which have undergone very little revision over the past 200 years



History of Occupational Medicine in Aviation

- ◆ First fuel used was a castor oil mix for lubrication
- ◆ Front positioned engine caused a continual mist of castor oil to be sprayed across the pilot's face
- ◆ Aviators wore long scarves to wipe mist from their goggles and cover their mouths & noses
- ◆ What did the ingested/inhaled castor oil do to the aviator?



History of Occupational Medicine in Aviation

- ◆ Currently more than 1 million personnel work in the aerospace environment
- ◆ Each of these occupations is exposed to toxicological hazards that are unique to their occupation



Check On Learning

- ◆ Who was the first to describe the relationship between work and illness?
 - ▶ Hippocrates (400 B.C.)
- ◆ What was the first fuel used in aviation?
 - ▶ Castor oil mix



ELO B

- ◆ ACTION: Match the terms with the correct definitions relating to toxicology
- ◆ CONDITION: Given a list of terms and a list of definitions
- ◆ STANDARDS: IAW TC 3-04.93 and Fundamentals of Aerospace Medicine

Terms & Definitions

- ◆ Occupational Hazard
 - ▶ Anything capable of producing an adverse health or safety effect on an individual

- ◆ Toxicology
 - ▶ The scientific study of poisons

- ◆ Exposure
 - ▶ The actual contact of the harmful substance with the biological organism

Terms & Definitions

Types of Exposure:

◆ *Acute Exposure*

- ▶ Exposure to an agent over a short period of time that causes adverse health effects

◆ *Chronic Exposure*

- ▶ A long-term exposure to an agent or a series of repeated exposures to an agent that may eventually lead to adverse health changes

Terms & Definitions

- ◆ Threshold Limit Values (TLV)
 - ▶ Concentrations of a chemical that will produce no effects to individuals who are exposed for 8 hours a day

- ◆ Short Term Exposure Limits (TLV-STEL)
 - ▶ Concentration of chemicals that are allowed for exposure times of 15 minutes during the work day

- ◆ Ceiling Concentration (TLV-C)
 - ▶ Concentration of a chemical that must never be exceeded during any part of the workday

Check On Learning

- ◆ What is the definition of a hazard?
 - ▶ Anything capable of producing an adverse health effect (injury or illness)
- ◆ What are two types of exposures?
 - ▶ Acute and chronic

ELO C

- ◆ ACTION: Match the aviation toxicology principle with its definitions
- ◆ CONDITION: Given a list of terms and definitions
- ◆ STANDARD: IAW TC 3-04.93 and Fundamentals of Aerospace Medicine

Toxicology Principles

- ◆ Time and Dose
- ◆ Route of Entry
- ◆ Rate of Retention and Excretion
- ◆ Physiological Effects
- ◆ Physiochemical
- ◆ Environmental

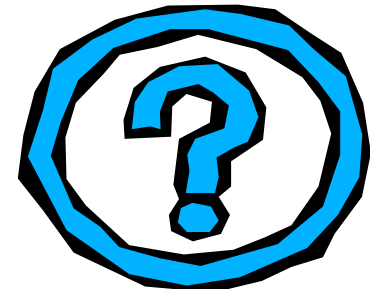
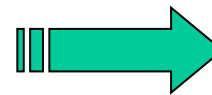
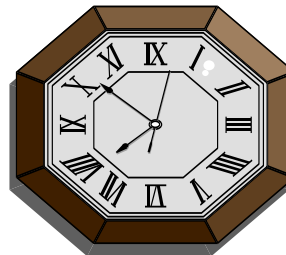
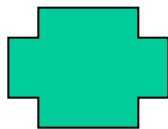
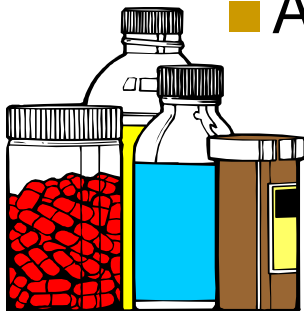
Toxicology Principles

◆ Time and Dose

- ▶ Toxin effects depend on the amount and duration of exposure

◆ Route of Entry

- ▶ Ways a toxin can enter the body
 - Inhalation
 - Ingestion
 - Absorption



Toxicology Principles – Route of Entry

◆ Inhalation

- ▶ Most likely method of getting a toxin into the body in the flight environment



Toxicology Principles – Route of Entry

◆ Ingestion

- ▶ Involves taking a toxin orally
- ▶ Smoking, eating, or drinking in the work area without adequate precautions is the primary means of exposure



Toxicology Principles – Route of Entry

◆ Absorption

- ▶ Involves movement of a toxin through the skin
- ▶ Prolonged contact with most petroleum, oils, lubricants (POLs) may allow for dermal absorption
- ▶ Physical handling of a toxic product is not the only method of absorption

- Fuel contaminated clothing



Toxicology Principles

◆ Rate of Retention and Excretion

▶ Retention

- How long a toxin will remain in the body

- Toxins with high retention rates:
lead, DDT, Asbestos, Beryllium

▶ Excretion

- How quickly the body rids itself of the toxin

- This is usually through which organs?

Toxicology Principles

◆ Physiological Effects

▶ Individual variables that determine the response to a toxin

■ Metabolism

- Age
- Concurrent medication

■ Body fat

- Determines the effect fat soluble toxins have on the body

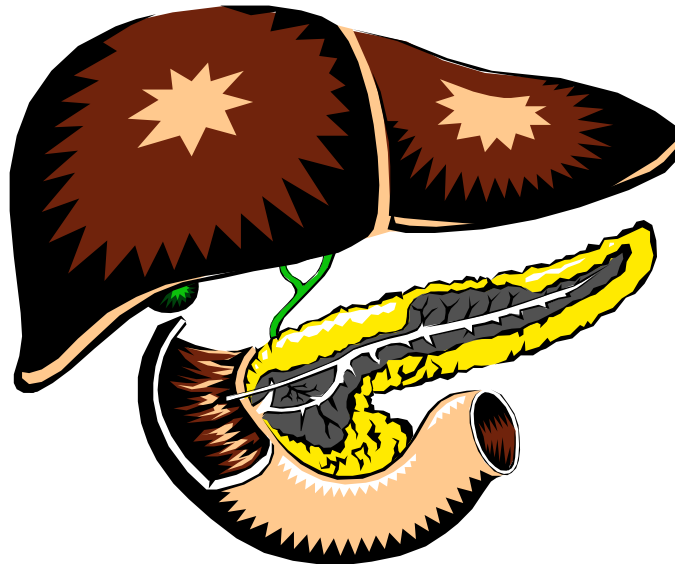
■ Genetics

- Ethnic group
- Sex

Toxicology Principles

◆ Physiochemical

- ▶ Biochemical process of detoxifying chemicals within the body



Toxicology Principles

◆ Environmental

▶ Toxicity may be affected by:

- Atmospheric pressure

- Temperature

- Humidity



Toxicology Principles - Environmental

- ◆ Atmospheric pressure
 - ▶ FAA studies show that hazardous fumes become more toxic at higher altitudes



Toxicology Principles - Environmental

◆ Temperature

- ▶ Toxic agents are less problematic in the winter than summer due to the larger vaporization of volatile chemicals in warmer temperatures



Toxicology Principles - Environmental

◆ Humidity

- ▶ Chemicals are more rapidly absorbed through wet (perspiration) skin than cool dry skin



Check On Learning

- ◆ What are the three routes a toxin can enter the body?
 - ▶ Inhalation, skin (absorption), and ingestion
- ◆ Which two organs are responsible for excretion?
 - ▶ Kidneys and liver

ELO D

- ◆ ACTION: Match the aviation toxic substance with its hazard
- ◆ CONDITION: Given a list of aviation toxic substances and a list of hazards
- ◆ STANDARD: IAW TC 3-04.93, AR 50-5, and AR 50-6

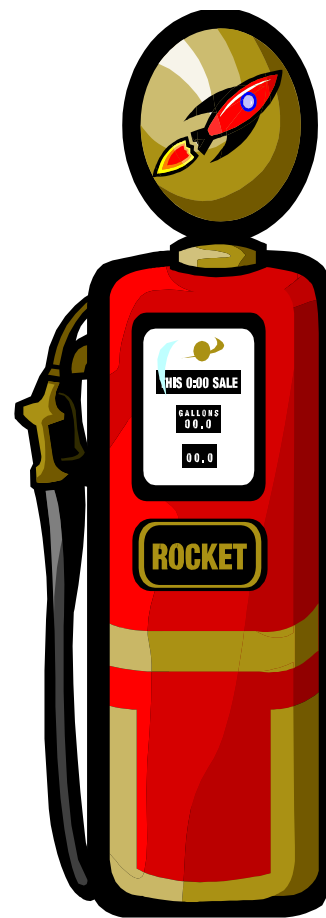
Toxic Substance Overview

- ◆ Aviation fuels and fuel combustion products
- ◆ Solvents and degreasers
- ◆ Lubricants
- ◆ Hydraulic fluids
- ◆ Fire extinguishers
- ◆ Composites and plastics

Aviation Toxic Substance

◆ Aviation fuels

- ▶ Combination of multiple (>20) petroleum products
- ▶ Principal hazard is vapor inhalation
- ▶ Known carcinogens:
 - Toluene
 - Xylene
 - Benzene
 - Naphthalene
- ▶ Army jet engines use JP-8
 - Kerosene (principal agent)
 - Flash point of 100 F°



Aviation Toxic Substance

Aviation Fuel Symptoms of Acute Exposure

◆ **Neurological symptoms:**

- ▶ Light-headedness
- ▶ Confusion
- ▶ Fatigue
- ▶ Coma
- ▶ Slurred speech
- ▶ Impaired psychomotor

◆ **Gastrointestinal symptoms:**

- ▶ Nausea
- ▶ Vomiting
- ▶ Easily absorbed through mouth

◆ **Skin symptoms:**

- ▶ Chemical burns
- ▶ Irritation due to the drying effect

◆ **Cardiac and Respiratory symptoms:**

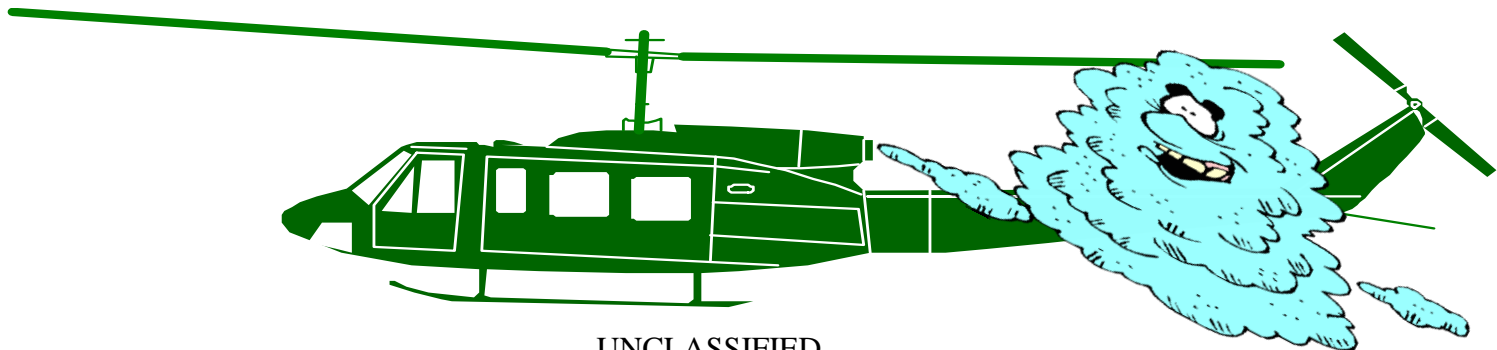
- ▶ Irregular heart beats
- ▶ Respiratory failure
- ▶ Coughing
- ▶ Choking
- ▶ Wheezing

Aviation Toxic Substance

◆ Aviation fuel combustion

▶ Carbon Monoxide

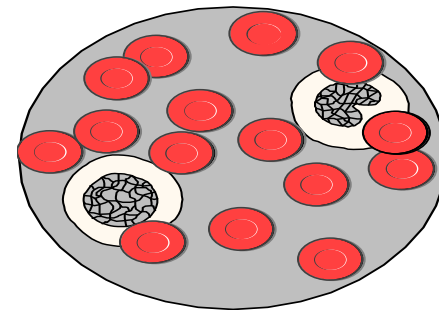
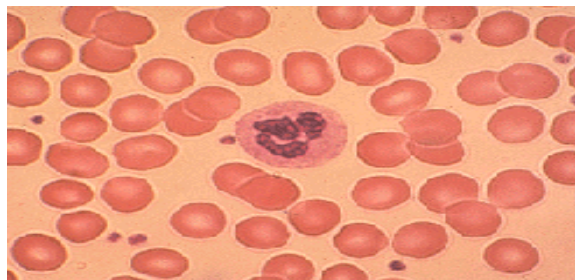
- One of the most common and toxic of substances in the aviation environment
- Low concentrations over time can produce high blood concentration



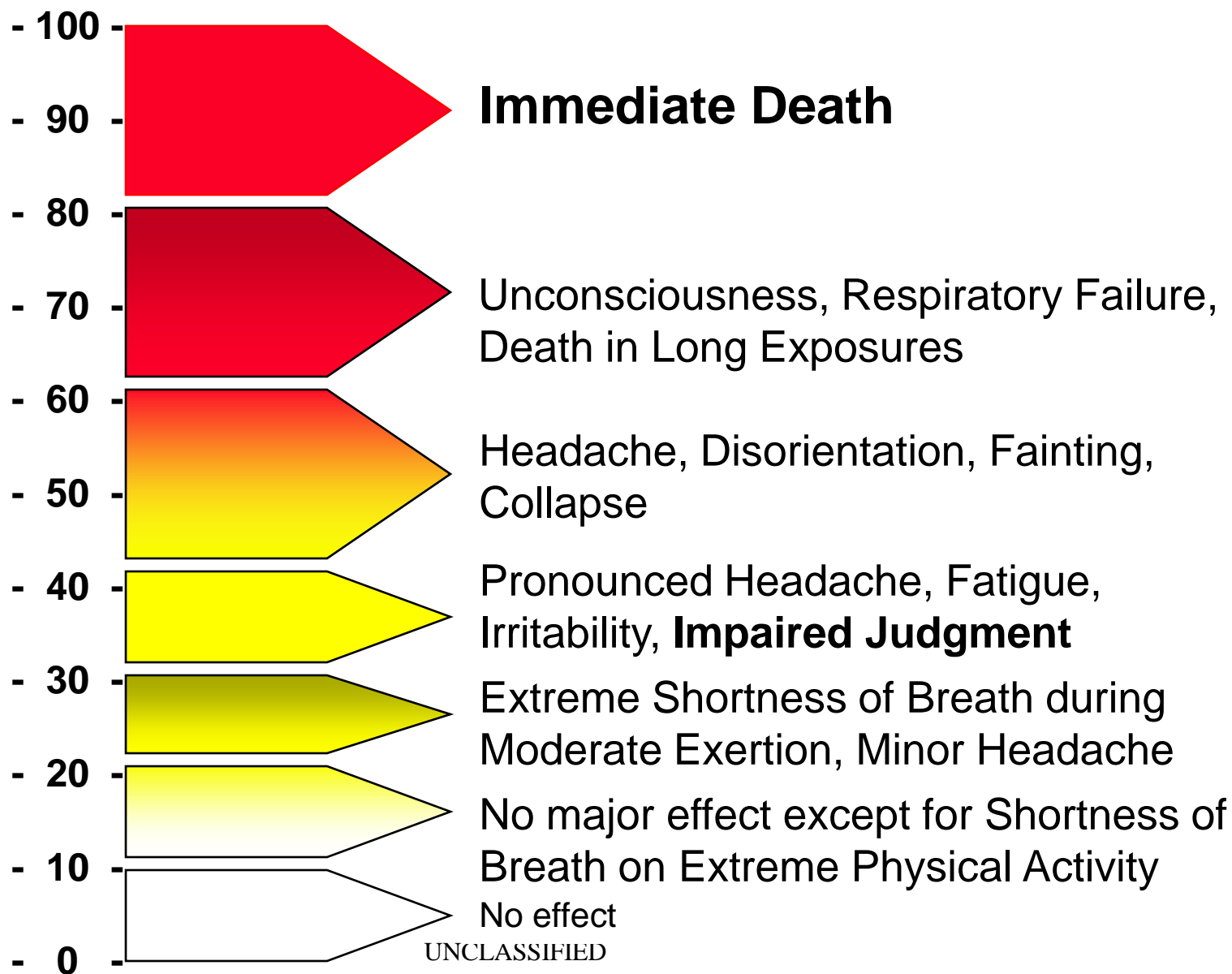
Aviation Toxic Substance

◆ Carbon Monoxide

- ▶ Most common cause of fatal poisonings in USA
- ▶ Product of incomplete combustion
- ▶ CO is a colorless, odorless gas
- ▶ Inhaling 0.5% CO for 30 minutes = blood concentration of 45%
- ▶ As little as 10% concentration of CO in the blood can decrease peripheral and night visual acuity
- ▶ About 50% removed from the blood every 4 hours



Carbon Monoxide (Symptoms)



Aviation Toxic Substance

◆ Solvents and degreasers

- ▶ Organic bases used to dissolve other petroleum products (water, lipid):
 - Toluene Isocyanate - an additive to paints, foams, and adhesives
 - Trichloroethylene (TCE) - used in aircraft maintenance as solvent or degreasing agent
 - Methyl-ethyl-ketone (MEK) - solvent specified by the maintenance manual

Aviation Toxic Substance

◆ Lubricants

- ▶ Substances that reduce friction
- ▶ Located in engine, APU, transmission, and gear boxes
- ▶ When exposed to hot surfaces an inhalation hazard is produced with symptoms similar to CO
- ▶ Skin contact causes a dermatitis reaction

Aviation Toxic Substance

- ◆ Hydraulic fluids
 - ▶ Petrolatum, castor oil, silicon, or phosphate based
 - ▶ Maintained under high pressure and a small leak can produce a finely aerosolized mist in the cockpit
 - ▶ Fine mist can impair vision and act as an irritant
 - ▶ Large leak can cause pooling in the cockpit
 - ▶ Inhalation can irritate the lungs



Aviation Toxic Substance

◆ Fire extinguishers

- ▶ A threat when operated in an enclosed or open environment
- ▶ Inhalation is the primary threat

◆ Three types

- ▶ Halon
- ▶ Carbon Dioxide
- ▶ Aqueous Film Forming Foam



Fire Extinguishers

◆ Halon

- ▶ Liquefied, compressed gas that chemically interrupts combustion
- ▶ Non-toxic unless discharged within an enclosed space
- ▶ Decomposes into hydrogen fluoride, chloride, bromide and phosgene



Fire Extinguishers

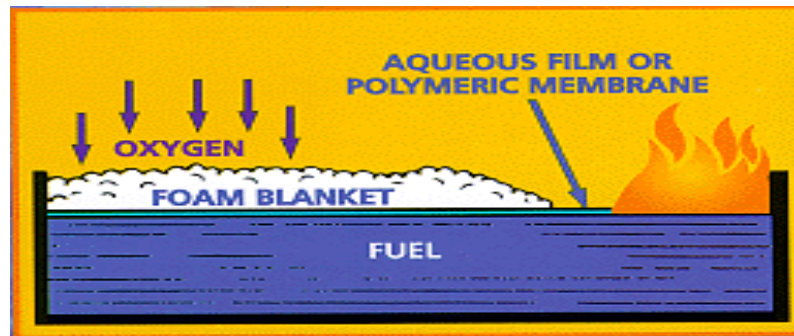
◆ Carbon Dioxide

- ▶ Safe, large quantities needed
- ▶ Heavier than air
- ▶ In low concentrations ($< 2\%$) acts as a respiratory stimulant
- ▶ High concentration (2-5%), drowsiness, headache, respiratory and loss of concentration
- ▶ At 10% or above, collapse, LOC, and death can occur



Fire Extinguishers

- ◆ Aqueous Film Forming Foam (A.F.F.F.)
 - ▶ Combination of fluorochemical and hydrocarbon surfactants
 - ▶ Relatively nontoxic detergent
 - ▶ The concentrated foam is harsh and can irritate the skin



Aviation Toxic Substance

◆ Composite and plastics

- ▶ Composed of a number of components which give:

- Strength
- Thermal resistance
- Light-weight

- ▶ Composed of:

- Resins
- Fibers
- Solvents



Composites and Plastics

◆ Fibers

▶ Include:

- Graphite
- Boron
- Kevlar
- Fiberglass

▶ Problems occur during:

- Crash
- Working
- Burning
- Sanding/scraping

▶ Primary hazard is inhalation of particles < 3.5 micrometers

▶ Asbestos-like reactions may occur

Composites and Plastics

◆ Resins

- ▶ Bonding agents that hold the fibers in a matrix
- ▶ Bonding agents composed of:
 - Epoxy
 - Polyurethane
 - Phenol
 - Amino resins
- ▶ Primary hazard is inhalation due to thermal release of toluene diisocyanates or methylene dianiline (MDA) fumes

Composites and Plastics

◆ Plastics

- ▶ Polyurethane used in cockpit/cabin interiors and fluorocarbon plastics used in wiring insulation and corrosion resistant coating
- ▶ Primary hazard is inhalation during decomposition which may release:
 - Cyanide
 - Fluorine gas
 - Phosgene



Check On Learning

- ◆ What toxic substances could you be exposed to in aviation?
 - ▶ Aviation fuels and their combustion products, composites, plastics, solvents, degreasers, lubricants, hydraulic fluids, and fire extinguishing chemicals



ELO E

- ◆ ACTION: Identify protective measures to prevent or reduce toxic substance exposure
- ◆ CONDITION: Given a list
- ◆ STANDARD: IAW TC 3-04.93, AR 50-5, and AR 50-6

Protective Measures

◆ Individual

- ▶ Prevent contamination of your AACU / NOMEX flight suits
- ▶ Smoke and eat only in authorized areas
- ▶ Hand washing decreases risk of ingesting a toxin
- ▶ Wear personal protective equipment (PPE)
- ▶ Pay attention to your physical symptoms:
 - Headache
 - Burning eyes
 - Choking
 - Nausea
 - Skin irritation

Protective Measures

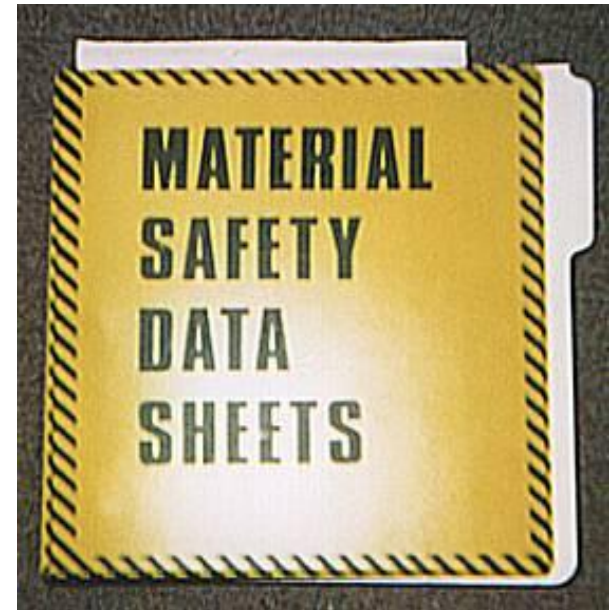
◆ Cockpit

- ▶ Be aware of the potential for toxic exposure in flight
- ▶ Smoke and fumes are a very serious matter
- ▶ Take immediate action:
 - Ventilate
 - Descend
 - Land
 - Evacuate the aircraft
 - Seek medical evaluation

Protective Measures

◆ General

- ▶ Be aware of the potential for toxic exposure in the aviation environment
- ▶ Be aware of the hazardous material in your work area
- ▶ Develop and rehearse evacuation plan



Check On Learning

- ◆ What type of combustion forms Carbon Monoxide?
 - ▶ Incomplete

- ◆ When might fire extinguishers using Halon or Carbon Dioxide be toxic?
 - ▶ In a confined or enclosed space

Summary

- ◆ Toxicology terms and definitions
- ◆ Toxicology principles
- ◆ Toxic substances in aviation
- ◆ Protective measures

Conclusion

